Back

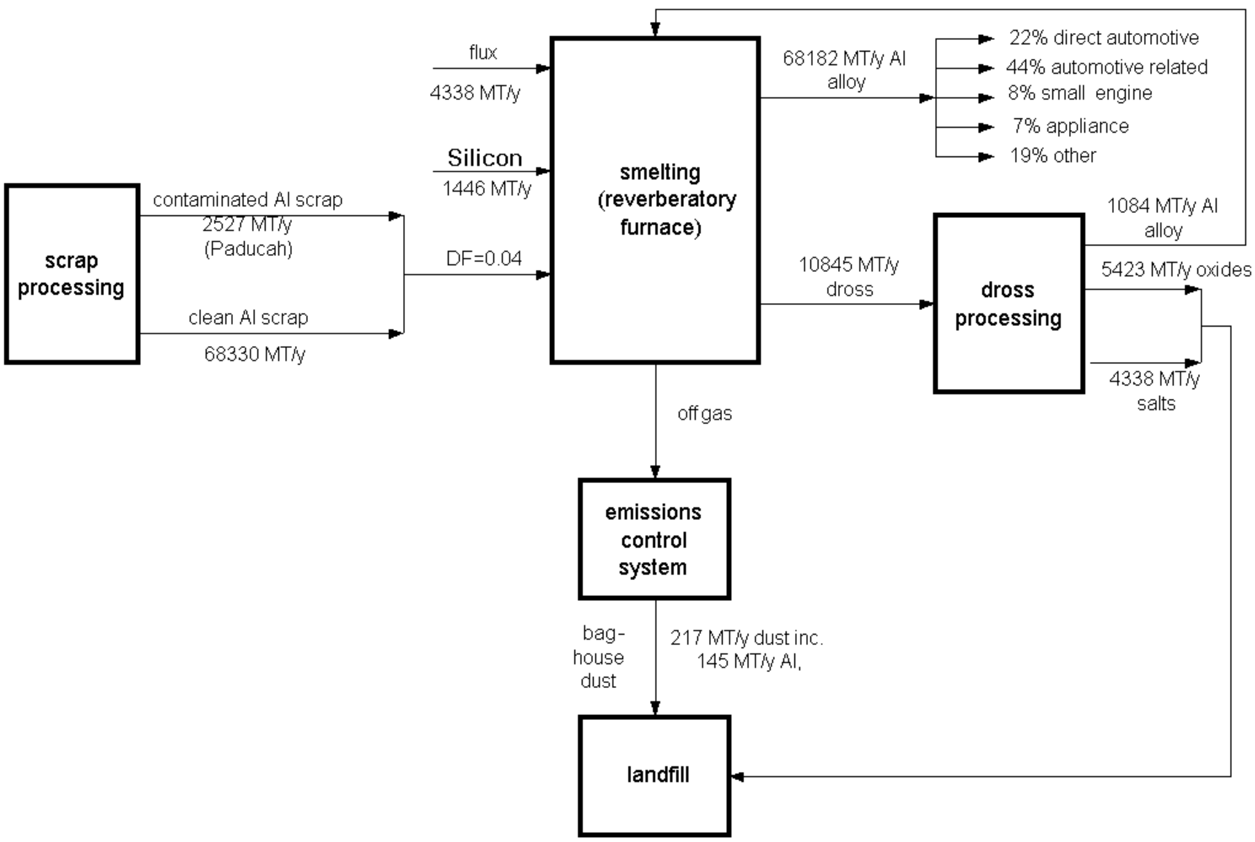

Figure B-6. Simplified Material Balance for Secondary Aluminum Smelter

- Dross . . . . 150 kg, containing 60 kg of salts, 15 kg of Al, and 75 kg of oxide

This simplified material balance, which is illustrated in Figure B-6, ignores the minor effects of Cl_2 injection and Mg removal. The material flows in Figure B-6 are for a full year.

Karvelas et al. (1991) quoted processing results from secondary aluminum smelters in the United States in 1988. For each 1,100 tons of aluminum produced, 114 tons of black dross and 10 tons of baghouse dust were generated. The composition of the black dross was 12% - 20% Al, 20% - 25% NaCl, 20% - 25% KCl, 20% - 50% aluminum oxide, and 2% - 5% other compounds. That study yields results similar to the simplified material balance proposed here. Karvelas et al. reported that 17 tons of aluminum were recovered from every 114 tons of black dross in 1988.

B.6.2 Workers in the Secondary Aluminum Industry

Scrap Metal Transporter

If the 2,527 t of scrap to be generated at Paducah were transported by a truck with 22-ton (20-t) capacity to a secondary smelter 170 miles (~275 km) away, it would take 126 trips. A driver would be exposed to the residually radioactive scrap for about four hours during each trip. However, since haulage costs are not the deciding factor in selecting the recycling facility, it is plausible for the scrap to be transported a greater distance, in which case a single driver could be occupied full time, hauling the scrap one-half the time and returning with an empty truck (or hauling other cargo).

Scrap Handler

An operator is assumed to spend eight hours per day moving scrap from the stockpiles to the shredder or the furnace using a front-end loader with a five cubic yard bucket (the bucket would be loaded 50% of the time). In addition to exposure from the load being transported, he would receive additional external radiation exposure from the scrap piles and internal doses from dust inhalation or ingestion. The scrap is stored in piles and stacked bales of shredded metal. Assuming that the desired inventory level is 15 days' supply, a facility with an annual capacity of 68,000 t would typically have at least 3,000 t of inventory on hand. The actual inventory might be larger to accommodate special purchasing situations or seasonal needs.

Shredder Operator

A typical shredder operator is assumed to spend seven hours per day running a scrap shredder (Figure B-3). The operator is assumed to stand beside the scrap conveyor which transports a stream of scrap 3 ft wide by 0.5 ft deep, with a 50% bulk density. Less than half the scrap is shredded.

Furnace Operator

The furnace operator is assumed to do a variety of jobs in close proximity to the furnace. For example, he skims dross from the melt surface in the charging well using a mechanized skimmer on an extendable arm located at one side of the well. The operator sits in a booth on the skimming machine about 6 ft from the melt and transfers the dross to a container in front of the charging well. During the course of a week the operator spends 15 hours skimming dross, and 25 hours feeding alloying or fluxing agents into the furnace or performing other furnace-related work. Other work might include manually raking the furnace to remove bulk steel objects which settle to the bottom. This is done twice per shift and requires 30 to 45 minutes per event (Kiefer et al. 1995).

Ingot Stacker

Once the ingots are removed from the molds, they may require stacking onto pallets. According to Kiefer et al. (1995), this labor-intensive job requires a crew of four—two stackers and two forklift operators. The stackers pick up ingots from a rotary table and place them on a stacking pallet. It requires about 20 minutes for each stacker to load a 2,000-lb pallet. The forklift operators transport the pallets to a storage area. The stackers and the forklift operators trade jobs frequently during a shift.

Dross Hauler

Dross containing 10% Al (with Co, Fe, Mn and Tc) and 90% salts and oxides (including elements such as U, Pu, Np and Cs) might be shipped 400 miles (~645 km) by truck with a 20-ton (18-t) capacity. Approximately 11,000 t of dross—about 600 truck-loads—is produced each year at the reference facility described in Figure B-6 . A one-way trip would take over eight hours; therefore, transporting the dross would be a full-time occupation for four or five drivers.

Aluminum Fabricator

Plasma arc cutting (PAC), gas metal arc welding (GMAW), and gas tungsten arc welding (GTAW) are processes typically used in fabrication of aluminum structures. An extensive study has been made of the metal fume levels associated with these processes (Grimm and Milito 1991). Tests were conducted using an instrumented mannequin in a special room where the air flow did not exceed 15 ft/min (~ 5 m/min or 7.6 cm/s). The mannequin was instrumented to measure fume concentrations inside and outside a welding helmet. Both a wrought base metal (2090) and a cast base metal (A356) were tested with different weld filler metals (1100, 2319, and 4043). Fume measurements are summarized in Tables B-16 and B-17 and indicate that the maximum fume level observed inside the welder's helmet was 7.66 mg/m^3, associated with gas metal arc welding of alloy 2090. It is expected that the welder would be exposed to these fume levels no more than 50% of the time, with the balance of the workday involving setup, workpiece handling, and other operations.

B.6.3 Users of End-Products

Automobiles
The average amount of aluminum used in North American cars and light trucks is 250 pounds, 65% of which is recycled metal (IMCO 1997, Lichter 1996). The aluminum content in luxury and specialty cars is higher—for example, the Plymouth Prowler uses 963 lb of aluminum (Drucker Research Company 1998). The use of aluminum in cars is a fast-growing market, having increased 35% over the last five years. If this trend is sustained for another five years, the average recycled aluminum content can be estimated to be 220 pounds ($250 \times 1.35 \times 0.65$). Most of the recycled aluminum would likely be associated with under-the-hood components. Another author estimated that by 2010 domestic vehicles would use 283 pounds of aluminum castings ("Automotive Aluminum Recycling" 1994).

A recent study by the Drucker Research Company estimated that in 1999, the total aluminum content of passenger cars and light trucks will be 3.815 billion pounds based on 15.362 million units of production (Drucker Research Company 1998). Secondary aluminum made from old and new scrap will account for 63% of the 3.8 billion pounds (primarily as die and permanent mold castings). The total aluminum content per vehicle will average 248 pounds (of which 156 pounds will be secondary aluminum).

The largest single component is most likely the engine block. The approximate weight of a four-cylinder block is 40 lb (18 kg), a V-6 block weighs 55 lb (25 kg), while a V-8 ranges from 60 to 80 lb (27 to 36 kg) (Klimish 2001).

Home Appliances
Sources of exposure include ingestion of food cooked in cast aluminum frying pans[10] and external exposure to cast aluminum components in appliances. Aluminum usage in typical home appliances is as follows (Aluminum Association 1985):

- room air conditioners . . . . 10 lb
- ranges . . . . 2 lb
- refrigerators . . . . 10 lb

[10] Kitchen cookware is commonly made from wrought aluminum alloys such as 6061 rather than cast alloys. Some cast aluminum (e.g., 383 alloy) might be used for skillets (Graham 1997).

- dishwashers . . . . 2 lb
- washers . . . . 15 lb
- dryers . . . . 4 lb

Truck

The tractor of a large truck can contain about 700 lb of aluminum in the cab shell (including the sleeper compartment) and under the hood. On a long haul the driver is limited by Department of Transportation regulations to a maximum of 15 hours per day of driving and on-duty time, including a maximum of ten hours of driving. The driver is also limited to 60 hours of on-duty plus driving time in a seven-day period. On-duty time includes such actions as loading and unloading the vehicle. In addition, the driver may spend time resting in the sleeper compartment. However, the cab is made from a large number of aluminum parts and the likelihood of all the parts coming from the same heat of aluminum is nil. The largest aluminum component that is made from one or two pieces of aluminum mill products is assumed to be a 100-gallon fuel tank that is mounted on the left side of the cab behind and below the driver.[11] If such a tank were fabricated from $\frac{5}{16}$-inch aluminum sheet, it would weigh about 180 lb.

Motor Home

The floor of an aluminum motor home contains about 600 lb of aluminum. As is the case with the truck cab, the motor home will be constructed from a variety of shapes, making it unlikely that all the material would come from a single heat.

[11] The Freightliner C112 Tractor with 58-inch raised roof sleeper cab is configured in this way. According to a Freightliner spokesman, tanks weigh about 200 pounds.

Table B-16. Concentrations in Ambient Air Inside and Outside the Welder's Helmet During Aluminum Welding and Cutting

Component	Units	GMAW[a] 2090/2319		GMAW 2090/1100		GTAW[b] 2090/2319		GMAWA 356/4043		GMAWA 356/4043		GMAWA 356/4043	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
NO	ppm	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
NO_2		<0.01	<0.02	<0.01	0.03	<0.01	<0.01	<0.01	0.23	<0.01	<0.01	<0.01	<0.01
O_3		0.16	0.22	0.09	0.14	<0.01	0.08	0.28	5.75	0.16	0.68	0.06	0.18
Total fume	mg/m^3	7.66	42.9	5.76	27.4	0.20	0.57	1.14	14.5	0.73	4.96	0.78	2.82
Al_2O_3		7.12	40.60	5.71	25.97	0.05	0.23	0.96	13.97	0.70	3.48	0.36	1.59
SiO_2		—	—	—	—	—	—	0.12	0.99	—	—	—	—
Fe_2O_3		—	0.07	0.131	0.05	—	—	—	—	0.04	0.04	—	—
CuO		0.15	1.09	0.05	0.05	—	—	0.03	0.03	—	0.03	—	—
Cr_2O_3		—	—	0.04	—	—	—	0.03	—	—	—	—	—
MgO		—	<0.03	—	—	—	—	—	—	—	—	—	—
MnO		—	0.07	—	—	—	—	—	—	—	—	—	—
NiO		—	—	—	—	—	—	—	—	—	—	—	—
TiO_2		—	0.07	—	—	—	—	—	—	—	—	—	—
ZrO_2		—	—	—	—	—	—	—	—	—	—	—	—
Li_2O		—	0.06	—	—	—	—	—	—	—	—	—	—
Sb		—	—	—	—	—	—	—	—	—	—	—	—
BeO	$\mu g/m^3$	—	—	—	—	—	—	<2.91	28.40	<1.87	<3.30	<2.14	<1.87
Be		—	—	—	—	—	—	<1.04	10.22	<0.67	<1.22	<0.77	<0.67
Total oxides	mg/m^3	7.29	42.00	6.04	26.08	0.06	0.23	1.10	15.05	0.75	3.52	0.36	1.60
Oxide ÷ total fume	%	94.9	98.6	106.2	95.6	30.0	NV	92.1	104	122	73.6	53.7	68.9

Note: — indicates analyses completed, but values do not exceed lower limit of detection (LOD). (For SiO_2, LOD=0.03 mg/m^3, for all other oxides, except BeO, LOD=0.02 mg/m^3).

[a] Gas Metal Arc Welding

[b] Gas Tungsten Arc Welding

Table B-17. Dust Levels During Plasma Arc Cutting of Wrought Metal 2090 (mg/m^3)

Component	Inside Helmet	Outside Helmet
Total fume	3.40	3.28
Al_2O_3	2.65	2.25
SiO_2	—	—
Fe_2O_3	—	—
CuO	<0.03	—
Cr_2O_3	—	—
MgO	—	—
MnO	—	—
NiO	—	—
TiO_2	—	—
ZrO_2	—	—
Li_2O	0.16	.14
BeO ($\mu g/m^3$)	<1.40	<1.40
Be ($\mu g/m^3$)	0.50	<0.50
Total oxides (mg/m^3)	2.83	2.39
Total oxide/total fume (%)	71.4	66.5

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APPENDIX B-1

DESCRIPTION OF SELECTED SECONDARY SMELTERS

Table B1-1. Description of Selected Secondary Smelters

Facility	Bag House Type	Dust Disposal	Pretreatment	Dross Handling	Radiation Detectors	Furnaces
Ohio Valley Aluminum, Shelbyville KY	None	N/A	None	Skimmed into containers and sold	Not used	Three, 9.5 million lb/mo total
Rock Creek Aluminum, Rock Creek OH	??	??	Crushing and screening	N/A	Hand-held Geiger counter	60 million/y, no melting
Alcan Recycling, Shelbyville TN	On shredder, decoater, and furnaces. Furnace bags coated w/ $Ca(OH)_2$	BFI ships to secured landfill	Shredding and decoating	Sold to Tennessee Processors, Al repurchased	Fixed Ludlum detectors	Two reverberatory, 40 to 50,000 tons/y total
Sceptar Industries, New Johnsonville TN	On rotary furnaces but not on reverberatories	To on-site landfill	Very little preprocessing	Dross is remelted	Not used	Two reverberatory, three rotary 12-14 million lb/month
IMCO Recycling, Morgantown KY	Lime-coated bags. One ton of dust per 100 tons of feed.	Both on-site & off-site landfills used. On-site equivalent to Sub-Title C, although not required	Shredder			Rotary furnaces: reverberatory under construction, 220 million lb/y current capacity
IMCO Recycling, Uhrichville OH		Off-site				360 million lb/y
U.S. Reduction, Toledo OH	Unknown	Off-site	Large and small crusher and dryer	Shipped to independent process	Not used	Two reverberatory
Wabash Alloys, Dixon TN	Lime-coated bags	BFI to municipal landfill	Shredder	Shipped to company plant in Benton, Ark.	Fixed	Four reverberatory, 220,000 lb each, 150 million lb/y total.

APPENDIX B-2

SECONDARY ALUMINUM SMELTER OPERATIONS AT ARKANSAS ALUMINUM ALLOYS INC.

SECONDARY ALUMINUM SMELTER OPERATIONS AT ARKANSAS ALUMINUM ALLOYS INC.[12]

B2.1 FACILITY DESCRIPTION

Arkansas Aluminum Alloys, Inc. (AAAI) is an aluminum recycling facility (secondary aluminum smelter) that has been in business since 1974. AAAI produces aluminum stock with varied elemental composition depending on customer specifications. Approximately 165 employees (administration and production) work at the facility. The facility operates 24 hours per day, 355 days per year, with four rotating work shifts. Employees receive two 10-minute breaks and a 30-minute lunch period per shift. There are three gas-fired reverberatory furnaces at the smelter. However, except for times of extreme production demands, only two furnaces are operated at one time. Office, warehouse, and production space occupies 57,130 square feet, situated on nineteen acres. Smoking is permitted in the manufacturing areas.

B2.2 PROCESS DESCRIPTION

AAAI receives and processes all types of reclaimable aluminum scrap except cans. Most (98%) of the scrap aluminum is delivered by tractor-trailer truck, weighed, scanned for radioactivity, unloaded, and spread in the storage area. The scrap is then placed on a conveyor where it is visually inspected and manually sorted. Iron, stainless steel, zinc, brass, and other materials are removed at this station. The scrap is then sampled and analyzed and placed in storage bins based on elemental composition. AAAI has an on-site laboratory with a sophisticated elemental analyzer that requires very little sample preparation and provides rapid results. Some of the sorted scrap is shredded and crushed and screened to removed dirt. A magnet is used to separate iron from the aluminum. The shredded scrap is then placed in bins. A gas-fired kiln located at the back of the facility is used to dry machined turnings prior to processing in the melting furnace.

There are three 220,000-lb capacity gas-fired furnaces at AAAI. Each furnace is equipped with exhaust ventilation to control flue gas, as well as fume control (canopy hoods). Fume exhaust is conveyed to a roof-mounted baghouse system. Furnace runs last approximately 20 hours, followed by a 4½ hour pour time. The pour temperature of the melt is approximately 1380°F.

[12] Source: Keifer et al. 1995

About 80,000 lb of molten aluminum are left in the furnace to prime the next run. To charge the furnace, the furnace operator will open large overhead doors on one side of the furnace and use a front-end loader to place the scrap into wells adjacent to the furnace. After charging, the overhead doors are closed, and the scrap melts and flows into the main furnace body. Samples are periodically taken from the melt with a ladle and analyzed to ensure that the final product meets customer specifications (elements are added if necessary to meet customer requirements). Copper and silicon are the major elements added; this is done by placing into a hopper at the front of the furnace. The majority (over 95%) of AAAI customers purchase the finished aluminum in 30-lb ingots. AAAI will also accommodate those few customers who request 1000-lb aluminum "sows."

Magnesium is a common contaminant that must be scavenged (by demagging) from the melt to reduce the concentration below 0.1%. At AAAI, this is accomplished by injecting chlorine gas into the melt—piped from a 55-ton tank car, through vaporizers, to each furnace—via a graphite pump and carbon tubes. The chlorine combines with the magnesium to form $MgCl_2$, which is then skimmed off the top of the melt. If necessary, AlF_3 can be used instead of chlorine for this "demagging" operation. According to AAAI, AlF_3 is rarely used. Salt (NaCl), potash, and cryolite are added to every charge as a flux to remove dirt and prevent oxidation of the melt.

Iron is considered a major detriment to the product, and every attempt is made to eliminate it during initial inspection and by the use of magnetic separation prior to processing. However, some iron inevitably gets into the furnace, sinks to the bottom, and must be manually removed. Periodically (twice per shift), furnace operators manually drag a large rake along the bottom of the melt to pull the iron out of the furnace. Each raking event takes about 30 to 45 minutes.

During pouring, the furnaces drain into an insulated open trough. To start the pour, a furnace plug is removed and the molten metal flows continuously through the trough into 1½ ft long, 30-lb molds (or 100-pound molds if necessary). The 30-lb molds are on a carousel/conveyor system and pouring occurs as the molds move sequentially through a water bath. This area is shielded because of the potential for violent reactions in the event molten aluminum contacts the water. After the molds have passed through the water, two workers stand adjacent to the conveyor line and skim dross from the ingots using hoe-like hand tools. The ingot molds are then elevated on the carousel and rotated to release the ingots onto a conveyor belt. Graphite is used as a mold-release agent. An automated pneumatic hammer is used to remove the ingots from the molds if necessary.

The ingots are then conveyed to the stacking area where they are dropped onto a rotating table. The surface temperature of the ingots is approximately 230°F when received at the stacking station. Stacking is a 3- or 4-man labor-intensive operation (2 stackers, 2 forklift operators), and workers continuously rotate between stacking and forklift operation. As the ingots are deposited onto the table, the stacker will pick up the ingot and place it in position on a stacking pallet. Stackers are also required to inspect the ingots and recycle those found to be defective. Each stacker will load one 2000-lb stack (approximately 18-20 minutes), and then switch jobs with the forklift operator. The fully stacked pallets are then moved to a cooling room, and finally to the warehouse. AAAI has a fleet of trucks for shipping product to customers.

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